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Sar and Passive Microwave Observations of the Odden During Mizex '87

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Abstract

The “Odden” which is a protuberance of sea ice in the Greenland Sea Basin was studied using the NIMBUS-7 Scanning Multichannel Microwave Radiometer (SMMR) satellite and an X-band (3 cm) Synthetic Aperture Radar (SAR) aircraft. The sea ice, meteorological and oceanographic conditions within the northern portion of the Odden was additionally studied in March and April 1987 by scientists on board the M/V POLAR CIRCLE and R/V HAAKON MOSBY. The SMMR data which was first validated with in situ ship measurements and the SAR data observed rapid 2-3 day oscillations of the Odden ice edge. The oscillations at 74-75° were several hundred kilometers in extent. The rapid oscillation of the Odden does not appear to be a result of wind induced ice drift, but rather the rapid formation of thin ice off the main edge.

Eight years of NIMBUS-7 SMMR derived total ice concentration were studied in the Greenland Sea to observe Odden growth and decay. Using 75°N and 0° as a reference point, Table 3, which was generated from analysis of the NASA Goddard NIMBUS-7 SMMR derived ice concentration data recorded on a video tape, indicates the appearance and disappearance of the Odden. Examination of Table 3 reveals the initial formation of the Odden in December of most years and its general disappearance in late April. Note the absence of any Odden from 13 April 1983 to 13 February 1985.

The monthly variation of the Odden can also be obtained from Table 3. In general, the Odden forms in December and remains through February. During February, March, and April the Odden will sometime migrate (i.e, grow and decay) on a weekly basis dependent on local meteorological and oceanographic conditions.

TABLE 3. NIMBUS-7 SMMR Observation of the Odden Using 75°N and 0°E as a Reference Point

Date of Appearance	Date of Disappearance	Date of Appearance	Date of Disappearance
12-03-78	02-01-79	04-24-82	04-26-82
02-09-79	03-11-79	12-24-82	12-28-82
03-17-79	03-29-79	01-15-83	02-16-83
04-10-79	04-30-79	02-26-83	02-28-83
01-03-80	03-15-80	03-12-83	03-22-83
03-25-80	03-31-80	04-11-83	04-13-83
04-04-80	04-06-80	02-13-85	02-19-85
12-14-80	12-20-80	03-11-85	03-31-85
12-26-80	02-02-81	04-04-85	04-20-85
03-04-81	03-08-81*	12-24-85	12-30-85
12-11-81	04-08-82	01-02-86	01-29-86
04-14-82	04-16-82	02-06-86	03-02-86**

* With weaker concentration between 03-13-82 and 03-27-82
** End of data record

The eight years of Goddard processed SMMR data were also used to study the maximum extent of the Odden. On 14 January 1979 and 2 March 1986 the Odden extended out to approximately 5°E from 73°20' to 75°40'N. The areal extent of this maximum Odden condition when compared to the non-Odden April through October condition indicates 200,000 square kilometers of sea ice formed from approximately 73° to 76°N.

SMMR data from 27 March to 8 April 1987 (Figure 5) were studied in detail to ascertain the effect of wind (speed and direction), air and sea temperature on Odden formation. Figure 5 indicates the Odden area was relatively constant 27-31 March. From 31 March to 2 April the Odden decayed approximately 200 kilometers in that two day period. The Odden again increased in size (approximately 75 km) from the 4 April to 6 and 8 April 1987 time period.

Neglecting local ice formation and melting, this implies an unusually strong zonal ice drift in the Odden varying between 0.5-1.0 m/s. Assuming a free ice drift model the wind speed required to provide this ice drift is calculated to be between 25-50 m/s. Examination of the local winds in Figure 5 reveals that the maximum wind speed was 15 m/s during the 27 March to 8 April period.

Thus, a more feasible explanation is the rapid formation of thin new ice off the main ice edge. The typical mixed layer temperature off the ice edge in the East Greenland Sea during winter is less than -1° C with salinity ranging from 34.3-34.5 $^{o}/_{oo}$. In order to set up deep water convection and eventually form bottom water, the water must reach a salinity of about 34.9 $^{o}/_{oo}$ and a temperature of -1.3°C.

We must therefore seek a pre-conditioning mechanism such as upwelling of intermediate warm and saline water by eddy circulation or ice edge upwelling which then can be exposed to atmospheric cooling by which the surface temperature can drop to the freezing point (1.7°C for this salinity). We suggest that prevailing off-ice edge winds with air temperature of -10° to -20° for 2-3 days are sufficient to cause this drop. In addition to atmospheric cooling the importance of ice freezing subsequently followed by salt injection must be considered. Regular repeat of such events will significantly increase the salinity of the surface layer. The relative contribution of these two processed can be quantified by a simple model. The oscillations of the ice extent lead to significant changes in the vertical heat flux between the ocean and the atmosphere.

4. SUMMARY

NIMBUS-7 SMMR data and SAR aircraft data was used to observe rapid Odden ice formation in the East Greenland Current. The Odden sea ice protuberance forms typically in December of each year and disappears in mid to late April. The Odden which is not a result of wind induced pack ice drift, but rather new ice formation off the main ice edge encompasses 200,000 square kilometers and extends to 5°E at 75°N at its maximum extent. The Odden is composed of nilas 3-5 cm thick ice which transitions into 5-10 cm pancake floes. The Odden was observed to decay approximately 200 km in the two period between 31 March and 2 April.

The comparisons between the SAR and SMMR produced ice edge was quite favorable with the SAR edge (accuracy of 250 m) and the SMMR produced edge (50 km resolution) agreeing to within 25 km.

5. REFERENCES

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